FOOD OF LARVAL TUI CHUBS, *GILA BICOLOR*, IN PYRAMID LAKE, NEVADA[1]

David L. Galat[2] and Nancy Vucinich[3]

Abstract.— Four near-surface locations in Pyramid Lake, Nevada, were sampled for larval tui chubs (*Gila bicolor*) during summer and early fall 1979. Numbers of larvae collected were highest in mid-July. Zooplankton was the only food eaten throughout the survey; the cladoceran *Moina hutchinsoni* was the major species eaten at all locations. Another cladoceran, *Diaphanosoma leuchtenbergianum*, was also important to the diet of pelagic larvae, and the copepod *Cyclops vernalis* was eaten in significant quantities by nearshore fish. Changes in diet composition of larval tui chubs during summer corresponded to seasonal succession of zooplankton species in Pyramid Lake.

The tui chub, *Gila bicolor*, is a polytypic cyprinid native to drainage systems in Oregon, California, and Nevada (Moyle 1976). It is the most abundant fish in Pyramid Lake, Nevada, where adults constitute over 90 percent of gill net catches (Vigg 1978, 1981). A major role of this species in the economy of Pyramid Lake is as forage for the primary sport fish, the Lahontan cutthroat trout (*Salmo clarki henshawi*), which commonly attains trophy weights of over 3 kg (Snyder 1917, Kucera 1978, Galat et al. 1981).

LaRivers (1962), Langdon (1979), and Vucinich et al. (1981) provided information on food of adult and juvenile tui chubs in Pyramid Lake; Miller (1951), Kimsey (1954), and Cooper (1978) presented similar information for this species in other waters; and Williams and Williams (1980) described the food of related *Gila* species. We present data on abundance, distribution, and food of the previously uninvestigated larval phase of the tui chub in Pyramid Lake.

Methods

Two shallow littoral stations in Pyramid Lake (40° 00′ N, 119° 35′ W), one northeast and the other southeast of Sutcliffe, Nevada, were quantitatively sampled for larval tui chubs between 18 June and 9 August 1979. A metered 1 mm-mesh net, 0.5 m in diameter, was hand-towed along the surface at about the 1 m depth contour and parallel to shore. However, only 2 of 10 attempts at collecting larval tui chubs in the shallow littoral region were successful and only three larvae were captured. Because so few fish were recovered from these locations they are not discussed further.

Two deeper littoral locations were also quantitatively sampled for larval fishes: a surface pelagic station, northeast of Sutcliffe, Nevada, at the 72 m depth contour, and a surface nearshore station, southeast of Sutcliffe at the 5–10 m depth contour, were sampled every two weeks from 26 June through 26 October 1979. Larvae were collected with the 0.5 m net described above, towed 1–3 m below the surface behind a boat. Fish collected were immediately killed in MS-222 to minimize regurgitation and preserved in 10 percent formalin.

After identifying larvae as tui chubs and measuring their fork lengths (FL), the entire digestive tract was removed. Contents from a maximum of 10 nonempty larval tracts were pooled for each date and station where more than two fish were collected. All zooplankters recovered from larval fish were identified to species and enumerated under a compound microscope at 40–200X. Algae and unidentifiable matter (e.g., detritus and digested material) were never observed in substantial amounts and were not quantified.

Numbers of organisms recovered from guts were converted to carbon equivalents based on the average carbon content of whole

[1]The Colorado Cooperative Fishery Research Unit is supported by the U.S. Fish and Wildlife Service, Colorado Division of Wildlife, and Colorado State University.
[2]Cooperative Fishery Research Unit, Colorado State University, Fort Collins, Colorado 80523.
[3]Pyramid Lake Indian Tribal Enterprises, Star Route, Sutcliffe, Nevada 89510.

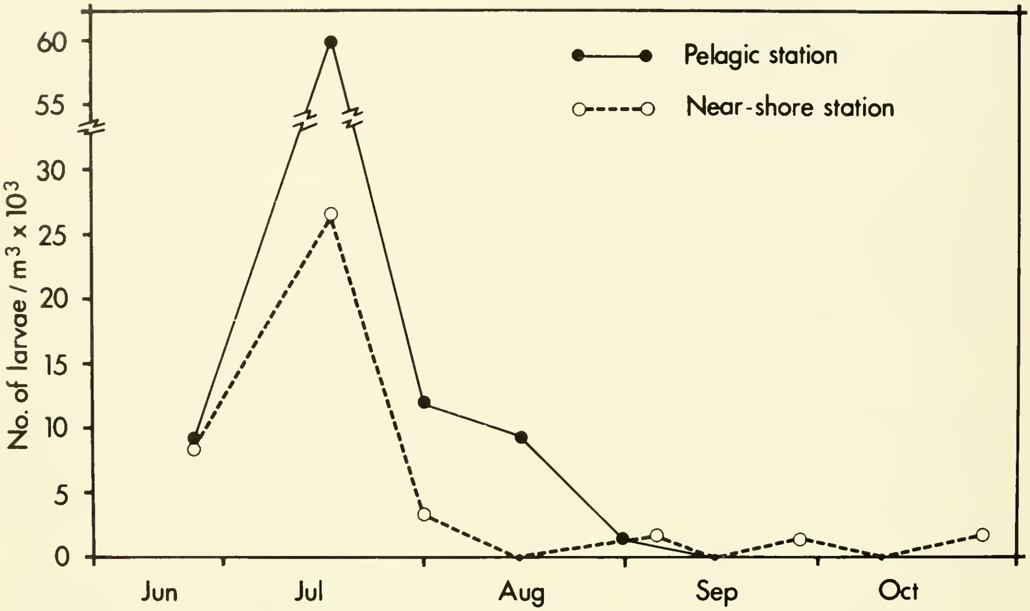

Fig. 1. Numbers of tui chub larvae collected near the surface at two locations in Pyramid Lake, Nevada, 1979.

organisms as measured with a Hewlett-Packard model 185B CHN analyzer, following Sharp's (1974) procedures. Because carbon values were not obtained for *Daphnia schodleri* or copepod nauplii, these organisms were assigned approximate carbon equivalents relative to their intact size. We selected this approach over volumetric or weight techniques because it more accurately reflected the bioenergetic significance of a food item to the fish's diet.

Results and Discussion

The length range of larval tui chubs captured was 6–15 mm. Following Snyder's (1976) terminology, only mesolarvae (<12 mm FL) and metalarvae (≥ 12 mm) were identified from our collections. Yolk sacs were not apparent in any larvae. The alimentary tract was straight and tubelike in larvae up to 13 mm long; in progressively larger fish it began to loop and swell anteriorly. The transition of fish from metalarva to juvenile occurred at a length of about 15 mm.

Estimated larval abundance at the pelagic and nearshore stations peaked in mid-July at 0.06 and 0.03 larvae/m^3, respectively (Fig. 1), when water temperature from the surface to a depth of 5 m was 21 C. This period coincides with the reported time of peak tui chub spawning in Pyramid Lake (Kucera 1978). By September few larvae were collected at the surface nearshore station, and none at the surface pelagic site.

Digestive tracts from tui chubs taken on four pelagic and three nearshore sampling dates, totaling 25 and 14 larvae, respectively, were examined. Guts were usually one-half to three-quarters full and contained only zooplankton (Tables 1 and 2).

Moina hutchinsoni was the dominant zooplankter recovered from all pelagic larvae sampled and was also of greatest significance to larvae in two of three nearshore collections. *Diaphanosoma leuchtenbergianum* ranked second in importance among food items for pelagic larvae but was of minor importance among nearshore larvae. In contrast, *Cyclops vernalis* appeared in all three nearshore samples but was insignificant in pelagic larval stomachs. *Alona costata* was observed in larvae from two nearshore samples but was not recovered from pelagic larvae. Food items eaten in small amounts were *Eucypris* sp., *Branchionus* spp., *Daphnia schodleri*, and copepod nauplii.

We anticipated finding more rotifers and copepod nauplii in larval tui chub stomachs, particularly since these groups were abundant in littoral zooplankton samples (Vucinich et al. 1981). Kimsey (1954) reported that

TABLE 1. Pooled stomach contents of pelagic larval tui chubs from Pyramid Lake, Nevada. Carbon values are approximate and represent reconstructed organisms. Numbers in parentheses are subtotals for the various categories.

	June 26			July 17			July 31			August 15		
Food item	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C
Cladocera	(8)	(22)	(98.7)	(32)	(88)	(99.7)	(55)	(150)	(98.4)	(50)	(139)	(96.8)
Moina	8	22	98.7	24	67	75.7	34	95	62.5	45	126	87.7
Diaphanosoma				7	18	20.5	21	55	35.9	5	13	9.1
Alona												
Daphnia				1	2.8	3.2						
Copepoda							(2)	(1.0)	(0.7)	(4)	(4.5)	(3.2)
Cyclops										1	3.0	2.1
Nauplii							2	1.0	0.7	3	5	1.1
Rotatoria												
Brachionus	1	0.3	1.3	2	0.5	0.6	5	1.4	0.9			
Ostracoda												
Eucypris												
Grand total	9	22		34	88		62	152		54	144	
No. tracts examined	3			14			7			6		
No. tracts with food	2			10			7			6		
Mean fish length (mm)	10.2			10.2			10.9			11.9		

newly hatched tui chubs in Eagle Lake, California, fed on rotifers, diatoms, desmids, and other microscopic material. Perhaps tui chub larvae smaller than those captured in the present study fed on these organisms.

Digestive tracts from larvae captured at the surface nearshore station contained more *C. vernalis*, *A. costata*, and *Eucypris* sp. than were recovered from larvae collected at the surface pelagic station. Conversely, *D. leuchtenbergianum* was more abundant in guts from pelagic tui chubs. A probable explanation for these differences is that the first three zooplankton taxa named prefer a benthic habitat and hence would be more available than *D. leuchtenbergianum*, a limnetic species, to nearshore tui chubs (Pennak 1978). Shifts in larval tui chub diet composition

TABLE 2. Pooled stomach contents of near-shore larval tui chubs from Pyramid Lake, Nevada. Carbon values are approximate and represent reconstructed organisms. Numbers in parentheses are subtotals for the various categories.

	June 26			July 17			July 31		
Food item	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C	No.	Total C (μg)	Percent Total C
Cladocera	(7)	(18)	(33.2)	(66)	(183)	(80.2)	(31)	(87)	(96.7)
Moina	2	5.6	10.9	60	168	73.6	31	87	96.7
Diaphanosoma				4	10	4.6			
Alona	5	12	22.3	2	4.6	2.0			
Daphnia									
Copepoda	(23)	(35)	(66.8)	(8)	(19)	(8.3)	(1)	(3.0)	(3.3)
Cyclops	23	35	66.8	6	18	7.9	1	3.0	3.3
Nauplii				2	1.0	0.4			
Rotatoria									
Brachionus				21	5.7	2.5			
Ostracoda									
Eucypris				3	21	9.0			
Grand total	30	53		98	228		32	90	
No. tracts examined	3			10			2		
No. tracts with food	2			10			2		
Mean fish length (mm)	10.3			12.8			12.8		

from *C. vernalis* to *D. leuchtenbergianum* and *M. hutchinsoni* as the summer progressed paralleled seasonal changes in the relative abundance of these zooplankton species in Pyramid Lake (Galat et al. 1981), suggesting that larval tui chubs, like adults (Langdon 1979), are opportunistic feeders.

ACKNOWLEDGMENTS

We thank the Pyramid Lake Paiute Indian Tribe for granting us permission to conduct this study. We also thank E. P. Bergersen, K. Hamilton-Galat, E. P. Eschmeyer, and D. Snyder for their critical review of the manuscript. Mark Coleman assisted with field collections and zooplankton identification. Study funding was provided by the Bureau of Indian Affairs under Contract 14-16-0008-974 to the U.S. Fish and Wildlife Service and Colorado State University.

LITERATURE CITED

COOPER, J. J. 1978. Contributions to the life history of the Lahontan tui chub, *Gila bicolor obesa* (Girard), in Walker Lake, Nevada. Unpublished thesis. Univ. of Nevada, Reno. 98 pp.

GALAT, D. L., E. L. LIDER, S. VIGG, AND S. R. ROBERTSON. 1981. Limnology of a large, deep, North American terminal lake, Pyramid Lake, Nevada, USA. Hydrobiologia 82:281–317.

KIMSEY, J. B. 1954. The life history of the tui chub, *Siphateles bicolor* (Girard), from Eagle Lake, California. California Fish Game 40:395–410.

KUCERA, P. A. 1978. Reproductive biology of the tui chub, *Gila bicolor*, in Pyramid Lake, Nevada. Great Basin Nat. 38:203–207.

LANGDON, R. W. 1979. Food habits of the tui chub, *Gila bicolor*, in Pyramid Lake, Nevada. Unpublished thesis. Humboldt State Univ., Arcata, California. 45 pp.

LA RIVERS, I. 1962. Fishes and fisheries of Nevada. Nevada State Fish and Game Comm. 782 pp.

MILLER, R. G. 1951. The natural history of Lake Tahoe fishes. Unpublished dissertation. Stanford University. 160 pp.

MOYLE, P. B. 1976. Inland fishes of California. Univ. of California Press, Berkeley. 405 pp.

PENNAK, R. W. 1978. Freshwater invertebrates of the United States. Wiley-Interscience, New York. 803 pp.

SHARP, J. H. 1974. Improved analysis for "particulate" organic carbon and nitrogen from seawater. Limnol. Oceanogr. 19:984–989.

SNYDER, D. E. 1976. Terminologies for intervals of larval fish development. Pages 41–60 *in* J. Boreman, ed., Great Lakes fish egg and larval identification: proceedings of a workshop. National Power Plant Team, U.S. Fish and Wildl. Serv. FWS/OBS-76-23.

SNYDER, J. O. 1917. The fishes of the Lahontan system of Nevada and northwestern California. U.S. Bur. Fish. Bull. 35(1915–16):33–86.

VIGG, S. 1978. Vertical distribution of adult fish in Pyramid Lake, Nevada. Great Basin Nat. 38:417–428.

______. 1981. Species composition and relative abundance of adult fish in Pyramid Lake. Great Basin Nat. 41:395–408.

VUCINICH, N., D. L. GALAT, AND M. C. COLEMAN. 1981. Size-class structure and food habits of young-of-year tui chubs (*Gila bicolor*, Girard), in Pyramid Lake, Nevada. Cooperative Fishery Research Unit, Colorado State University, Fort Collins. 64 pp.

WILLIAMS, J. E., AND C. D. WILLIAMS. 1980. Feeding ecology of *Gila boraxobius* (Osteichthyes: Cyprinidae) endemic to a thermal lake in southeastern Oregon. Great Basin Nat. 40:101–114.